A CASE STUDY OF THE USE OF A DECISION SUPPORT SYSTEM

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INTRODUCTION

Articles which describe the impact of interactive, conversational computers on high-level management, especially in strategic planning problem environments, are rare. It is also true that our understanding of the complex issues related to human information processing, cognitive behavior, and affective or motivational characteristics (particularly as they relate to man-machine systems) is at a relatively primitive state in terms of implementation/design support. This paper explores possible reasons for, and an approach to solution of certain aspects of this problem. This approach is operationalized by the construction of an interactive computer model designed to support management problem solving in a long range planning environment. Alternative experimental paradigms are suggested and contrasted for studying human behavioral characteristics and problems as they relate to management decision system (MDS) or management information system (MIS) implementation. Finally, a case study is presented where information relevant to the issues discussed here was gathered during the development of a corporate divisional plan by the corporation's president who used a specific computer planning model described below.

DISCUSSION OF THE PROBLEMS

Conversational computer systems and management science models appear to have not had the profound impact on management that was predicted in the early sixties [1]. One reason for this situation is that computer systems are often designed without a clear knowledge of the problem environment in which decision support is sought. Another reason is that

designers do not give computer systems much knowledge about the problem environments within which they seek to support important decisions. Further, designers often do not compensate for differences between their "style" and that of the community that the system is designed to serve. This could account for the lack of impact of computers on relatively "unstructured" problems in environments such as strategic planning. Perhaps a partial solution to this predicament may be to get more problem centered knowledge into computers and thereby make them more "intelligent" within a given problem context.*

The approach taken in this paper attempts to strike a convenient compromise between providing support which is so general that it is of little direct help to the person with the problem, and support which is so specific that it can only be useful in solving (or operating on) one particular problem. Thus, the system described below possesses some (rather general) knowledge of the problem area which is being considered, but it relies on the particular user to tailor its effect to his own situation.

In developing this system, a substantial amount of attention was paid to the fact that every new system environment which is proposed to help or support a manager in a decision environment creates a new problem for the manager: namely, to learn about the system. For very general tools this cost is substantial. The manager is required not only to learn how to understand the tool (a passive understanding) but also how to use it to operate on his problems (an active understanding). This "set-up" requires not only effort but also time. Thus the rewards of

*See, for example, Minsky, M. and Papert, S., Artificial Intelligence Progress Report, Artificial Intelligence Memo No. 252, MIT, January 1, 1972.

getting involved in the use of the new system are deferred in time, and the manager must be willing to risk a substantial investment (in particular of his time and energy) before any payoff is visible.

With the technology described here, we attempt to avoid this problem by constraining the manager in some dimensions (which we hope, and will present some evidence of below, are not terribly material to him) and in doing so provide him with some prior structure. This allows him to obtain return for his efforts with relatively little investment (either in terms of effort or time) and thus substantially limits the risks involved in deciding to try to use such a support system.

SUPPORTING VS. RESOLVING DECISION PROBLEMS

An important though somewhat hazy distinction can be made between so-called programmed and nonprogrammed decisions:

> Decisions are programmed to the extent that they are repetitive and routine, to the extent that a definite procedure has been worked out for handling them so that they don't have to be treated "de novo" each time they occur ... Decisions are nonprogrammed to the extent that they are novel, unstructured, and consequential. There is no cut-and-dried method of handling the problem because it hasn't arisen before, or because its precise nature and structure are elusive and complex, or because it is so important that it deserves a custom-tailored treatment. By nonprogrammed I mean a response where the system has no specific procedure to deal with situations like the one at hand, but must fall back on whatever general capacity it has for intelligent, adaptive, problem oriented action [2].

Problem environments can be characterized as structured or unstructured to the extent to which programmed or nonprogrammed decision procedures apply to them. Most interesting management decision problems appear to fall into the relatively unstructured category. A typical attitude which has prevailed in the past is that substantially unstructured problems are either 1) too trivial to require decision support or 2) so complex that it is impossible

to make support system technology relevant. A more useful design hypothesis might be that such problems are in general neither trivial nor impossible: they are just difficult to solve.

In addition, it may be much more constructive to initially attack the problems in terms of sub-problems and sub-decisions that can be <u>supported</u> rather than <u>solved</u> by a computer-aided decision process. This suggests that we look for aspects of the total problem where structure is recognizable and use the computer to improve and mechanize those aspects. Such sub-problems may include comparison operations, production of graphs or other data presentation, arithmetic or primitive logical operations. Here we are using our understanding of relatively common sub-problems to help us "parse" our real problems into more manageable parts. Thus, breaking a problem apart into sub-problems accomplishes two distinct things:

1) Problems rarely look alike, but often share common parts which can effectively be operated on, and
2) We are helped to structure our thoughts in an effective and useful way by suggesting what kinds of sub-problems might be particularly useful to attack.

Many human problems influence the success or failure of attempted MIS or MDS implementations. Decision makers may attend to the wrong criteria in solving even their most important problems and may have substantial resistance to change even in light of unsatisfactory current performance [3]. Individuals or groups who control certain information may not want to relinquish their control through adoption of a system that exposes their data to other functional areas of the organization [4]. Decision makers may distrust technically innovative ways of dealing with their problems, first, because

they can't afford the investment required to understand the innovation (a new mathematical model for instance) and, second, because they may fear a machine related takeover of some aspect of their job or responsibilities [1]. Perhaps more important, the decision maker cannot afford the risk of accepting model results as an input to an important decision process without understanding the model. Furthermore, people are often more sensitive to computer errors in data processing than to the same errors made by human processing [5].

Also, as was suggested briefly above, most information processing technology has, in the past, been "packaged" in such a way as to require that a manager assume substantial risks in attempting to acquire and use it. These risks often involve:

(1) Acquiring expensive computer hardware
(2) Building and supporting expensive software
(3) Incurring substantial time delays involved in accomplishing (1) and (2) and thus delaying potential returns.
(4) Incurring the costs and delays inherent in attempting to link such systems together.

It is small wonder, then, that successful applications of decision support technology are reported so rarely.

A common assumption in many MIS implementations is that expanding the availability of the data base to managers or increasing the quality and quantity of information available should lead to better decisions. In fact, most managers do not need more information and the models that they employ in dealing with this information are often primitive, simple, historical models [6, 7]. In many problem environments it may be much more fruitful to improve the information processing ability of managers so that they may

deal effectively with the information that they already have, rather than by adding to the reams of data confronting them, or by attempting to directly improve the quality of those data [6]. The system discussed here is directed towards this objective.

It is also important to note that in any unstructured environment, one of a managers most difficult tasks is to "find" a useful problem to work on. Pounds [8] discusses this problem at some length. One of the most valuable aspects of a decision support system is that it often suggests to managers (cf.the case study which follows) what problems might usefully be considered. This represents an important contribution to the managers ability to handle problems, particularly those which are "novel" in some sense. In this fashion, a system may generaly <u>aid</u> and <u>support</u> the managers problem finding (and problem solving) process by giving him the confidence to tackle new problems.

THE PROJECTOR PLANNING MODEL

In order to test many of these ideas, an interactive planning support system, called PROJECTOR, was implemented and tested on a number of students (including several practicing managers) at the Sloan School of Management, MIT. In order to understand the case study which will be presented, it is necessary to describe this model in a functional fashion.

The PROJECTOR system is a long range financial planning model for new enterprise, acquisition and project analysis. The system was designed and implemented by the authors*. The primary thrust of the effort was twofold: first, to bring together many of the advanced tools for long range financial planning into a single interactive computer model and, second, to provide an effective learning tool for graduate students and professionals studying financial management and long range financial planning. The underlying assumption was that graduate students of financial planning and development who were exposed to a realistic, professional planning tool would be better trained as a result. An overview of this planning system is given in the next section. More detail can be found in <u>The PROJECTOR On-Line Planning System</u> [9]. The design and implementation of PROJECTOR took place over a period of many months beginning with an early predecessor at a major U.S. chemicals and plastics producer. Throughout the entire design and implementation process, managerial users of the system were continuously consulted. The system went through several evolutionary stages at both the chemicals and plastics company and at M.I.T., largely as a result of strong continuous model user input from professional managers, professors and graduate students of management.

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*In the process of developing this system, Professors John D. C. Little, Gerald A. Pogue, Devendra P. Garg, and Henry M. Paynter provided much useful advice. They are, however, not responsible for any errors or omissions.

PROJECTOR is a user-oriented, interactive computer planning model designed to facilitate financial planning. It has report generation capabilities for decision makers who are not necessarily familiar with computer languages or operations. The primary thrust of the system is to support the cognitive skills of the sophisticated financial planner with the computational and storage capabilities of a high speed electronic computer.

Of the multitude of functions that high-level decision makers must perform in attempting to realize organizational objectives and goals, long range planning has perhaps the most profound impact on the success of the organization. Clearly then, it is essential that this key planning function be executed in a systematic, consistent and technically sophisticated problem solving environment. PROJECTOR is designed to provide that environment.

The model is designed to allow the long range planner to express his view of alternative capital investment policies or other financial ventures via a remote computer time sharing terminal and evaluate alternative strategies in light of factors he feels are important. Rather than force the decision maker to evaluate strategies and alternatives on the basis of a single arbitrary decision criterion such as net present value, discounted cash flow rate of return, profitability index, minimum cost, maximum profit, benefit/cost ratio, return on investment, return on sales, profit margin or payback period, the planning model allows complete freedom of decision criteria selection according to whatever the planner feels is appropriate to the particular situation. In its most fundamental sense, PROJECTOR is a <u>decision-support</u> system, relying heavily on the expertise and experiential background of the financial planner. Although the model is designed to address normal long range planning and report generating

functions, it is also valuable in "crisis" planning situations where time is short or when sudden changes in the long range planning or investment horizon become apparent.

Since PROJECTOR is a generalized model, with application to a wide range of long range planning problems, it is possible for the user to use a variety of options to obtain a custom tailored version of the model. All of this can be done without learning to program the computer and without dependence on a programming or operations research staff. The time spent in developing a model (at least initially) is small, and yet useful results can be obtained. All interactions between the computer model and the decision maker consist of English language words, sentences, or their abbreviations, and of course the input data needed to describe the financial planning problem to be explored. The computer, through the remote time sharing terminal, will ask in a conversational form for the relevant project data, for the computational options that the manager may or may not use in a particular situation and for the other financial factors that the manager considers important to his particular planning problem. The computer will request data only on factors that the manager indicates are relevant to the current application. In addition to the capabilities available in the planning model, it is possible for the manager or his staff to build their own models, submodels and other computer executed procedures to be used in conjunction with the standard PROJECTOR system. These special procedures might include, for example, a unique report generating function, a user supplied computational algorithm or a standardized data management routine. The special procedures are added in the form of FORTRAN language subprograms. Also, the experienced model user may enter input data and

model configuration parameters in the form of a brief data file to minimize the time used in setting up and evaluating alternative financial ventures. This is particularly useful when working on one particular problem over a period of time.

In addition to new enterprise, new product and project planning capabilities, PROJECTOR implements some relatively sophisticated management science models for forecasting. These include univariate and multivariate regression analysis as well as exponential smoothing with trend and seasonality analysis. Optimal exponential smoothing model parameters can be determined.

Merger and acquisition analysis is facilitated by the implementation of a model for determining the optimal mix of various merger target goals such as earnings per share dilution, post merger debt-to-equity ratio, percentage ownership, working capital requirements, and package fractions of common stock, cash, bonds and convertible preferred stock. The goal programming technique is used to aid the management decision maker and planner in realizing optimal strategies in the process of pre-merger planning and negotiation. Refer to Figures 1 through 6 and Tables 1 through 4 for further information on the organization of the planning system.

A CASE HISTORY OF A DIVISION PLANNING PROBLEM

The Scenario

The divisional planning project described here took place at a small New England manufacturing company which will be called Acrofabrication Industries, Inc. (Acrofab). The president of Acrofab was in the process of considering the incorporation of a new subsidiary, which will be called Vehicle Security Systems (VSS) for purposes of this discussion. Approximately

eighteen months before the formal process of divisional planning has been initiated, certain members of the Acrofab management group discovered what they believed to be a potentially lucrative new product need in a market segment adjacent to and complementing a rapidly growing consumer durable goods industry. Shortly afterwards, a research and development program was initiated to determine whether a product could be produced to satisfy reasonable cost constraints and the technological constraints associated with the perceived product need.

The research and development efforts were directed toward the development of an easy to operate and inexpensive security device for protecting certain classes of consumer durable products. The new security device was given the name "Interceptor" and a comprehensive market feasibility and research study were initiated as soon as the technical team at Acrofab were convinced that they could build Interceptor for a reasonable price. After several months of research and development activity, a prototype of Interceptor was completed and tested. Results of the prototype testing, which was done by Acrofab personnel, indicated that in fact Interceptor offered a much higher-level of security under several possible theft/intrusion variations than did existing competitive systems designed for the same purpose. These existing systems currently dominated ninety five per cent of the high security market for such products. Substantial increases in theft rates of products for which Interceptor protection was planned indicated that existing security systems certainly did not provide adequate protection for the target products. Further testing indicated that Interceptor was technologically superior to all existing competitive products. Interceptor prototypes functioned well and the security system was not frustrated by a

wide variety of commonly used intrusion or theft strategies. On the basis of a favorable product test and this market research program, a decision to go ahead with the division plan was made.

The Divisional Organization

It was decided that the Vehicle Security Systems (VSS) division would be incorporated separately as a wholly owned subsidiary of Acrofab. This strategy was based on the high degree of risk and uncertainty of launching even a technically superior product into a market dominated by well entrenched nationwide organizations. As a result of the VSS divisional organization, VSS would have to seek support from the financial community on the basis of its own merits, without the benefit, for instance, of parent company joint liability arrangements. Of course Acrofab would be willing to invest some of its own capital in VSS but the president felt that the risks were too great and too poorly understood to make unlimited funding available from the parent company to VSS. At this point the president decided that he needed to obtain some support to aid in the development of a comprehensive divisional plan that would be essential for internal planning purposes and would be a valuable selling point when he was seeking formal external financial support for the VSS division.

The president was interested in examining several different issues related to launching the new division and the Interceptor product line. The historical objectives of Acrofab had been to offer its clients good delivery service (minimum lag between order entry and shipping date) and high quality manufactured merchandise while trying to maintain minimal working capital investment and low variable costs. Various sub-objectives included maintaining capital structure and organization product interdependency within prespecified bounds and controlling the level of risk involved in corporate ventures through

various classical methods of planning and analysis. With such conflicting and dimensionally incompatible objectives and subobjectives it was obvious that no optimal plan could be determined even if there were much less uncertainty in the new product market.

Initial Steps

The president had some formal analytical training since he had obtained an M.B.A. degree from a technically oriented graduate school of management. He decided to obtain technical assistance in the form of a professional consultant to help in setting up some kind of formal planning model to aid in the analysis of the new division. At the time of his original outside contact with the consultant, he was not sure of what type of formal model he needed or in what way such a model might be implemented at Acrofab. He did, however, have very well defined questions about issues that he wanted to explore in relation to the VSS division and he had collected (or estimated) a substantial amount of data relative to the major divisional issues. In fact, at that time he had substantially more data than he had ideas of what to do with it.

The president wanted to use an analytical model to gain insight into questions such as what levels of inventory and other working capital components would be appropriate for a given level of production and sales. More importantly, what would happen to his cash flow situation if these variables began to change rapidly or failed to meet the expected levels? In mapping out the original version of the divisional plan, the marketing department had specified a marketing life cycle analysis to be used in the financial calculations (see Figure 8). The president felt that it was very important to determine the sensitivity of total project profitability and value to changes in the deterministic product life cycle assumptions. Specifically,

what would be the impact of changing the slope of the life style curve or expanding or contracting the estimated horizon to product maturity and decline? What about the impact of increases or decreases in total product life sales on the profitability of the new division?

The president knew that these issues could have a profound impact on the value of the proposed new division to Acrofab. Furthermore he was concerned about basic relationships between investment in working capital, total production, variable costs, actual cash flow and project acceptability. The dynamics of the market place itself were of major interest since changes in that environment had seemed to create a need for the new product in the first place. The president wanted to know at what rate the market was growing in various segments and how the content of the market was changing along lines such as average target customer group age, sex, economic classification, etc. He felt that he could benefit by model based support in predicting some of these changes for the division plan analysis. He was interested in determining the impact of various specific marketing strategies on expected short term market penetration, eventual market share and total divisional profitability. For instance he wanted to simulate the effect of offering dealers a free unit of the Interceptor system for every three that they sold to encourage initial stocking.

The Model Implementation

The president had little experience with planning systems or models when the new VSS division analysis began, except for an exposure to cash budgeting models. He knew enough about computers, mathematical modeling and interactive management information systems to know that they could potentially benefit him but he wasn't sure of exactly how they might be

brought to bear on his problem. The possibility of a large scale stochastic simulation model was discussed in the initial problem exploration period. The simulation would be a sizeable undertaking designed to model interactions between production processes, financial considerations, and the dynamics of the market place. After all, a substantial amount of raw data had already been collected.

This idea was rejected fairly early in discussions of the modeling problem. The president felt much less comfortable in estimating expected values, variances, covariances, serial correlation coefficients, or cummulative probability functions than he did with making point estimates of model parameters and data, and then doing a sensitivity analysis on these. It wasn't that he didn't understand the statistical models, or that he didn't believe that they were a legitimate way of looking at the problem; he just couldn't personally identify with that mode of analysis, and in addition, he wasn't sure of what would be involved in building the model. Actually, it appeared that a significant research effort would be necessary to obtain a clear understanding of the critical variables and their interaction before such a model could be built. More importantly, he needed some form of assistance immediately, and such a model building effort could require a substantial expenditure of time and money.

The consultant suggested that a relatively simple interactive computer planning model be implemented initially to explore gross representations of the problem. The feeling was that this strategy might point out sensitive issues that could be explored and attended to in greater depth later. The model was implemented using the PROJECTOR interactive planning system (described in the previous section), primarily because of the consultant's familiarity with this system. Since this model is an English language oriented system, the president had little difficulty in mastering

the command structure and building a simple discounted cash flow investment analysis model of the VSS division. After experimenting with this for awhile, he decided that he was ready to look at a more detailed, disaggregated model of the new division. Over a period of several terminal sessions, he began to build more and more complex assumptions into the model, doing sensitivity analysis and later regression analysis on marketing and cost data (See Figures 2 and 3). He was soon making relatively sophisticated demands on the system.

Since this strategic planning problem could not be solved with any automatic decision making or optimization algorithm imaginable, it was imperative that the president clearly understand the model he was using for internal planning purposes and for documenting his venture capital seeking efforts. Clearly, there was a pressing time constraint; no defensible patent could be made to protect Interceptor from competition and market entry timing was critical. Since the president added complexity to his originally simple cash flow investment analysis model only as he saw fit, he did understand the details of the final models on which he based the majority of his decisions.

The Results

The results of using the model were sometimes quite surprising to the president. He reported that during the conversational data entry process in one of the PROJECTOR sub-models, he was forced to think about issues he would not have considered otherwise. This did not necessarily mean that he applied all of the options possible within the sub-models. But the fact the he at least considered a certain issue and rejected it as being inappropriate for his particular planning problem, made him more confident in the result of the total planning process. In evaluating his use of the computer planning model, which he agreed to do in advance

of the model implementation, he claimed that a nontrivial benefit of the problem modeling experience was educational in nature. He felt a new respect for sensitivity analysis and contingency analysis as a result of surprising discoveries of extreme sensitivity of total division profitability on a discounted cash flow basis to relatively minor changes in working capital investments and dynamic effects of lags in certain cash flow elements. His conclusion was that he would need more initial capital and that he had greatly underestimated total project working capital requirements in the preliminary division plan. For instance, in his original cash flow analysis, it did not occur to the president that he should recover his working capital investment in the final year of the project analysis. Since discounted cash flow analysis forces the analyst to put an arbitrary project termination data into the model assumptions, it is often necessary to recover investments in working capital and previously unrecovered depreciation in order to realistically reflect true project value. When the president moved from the simple cash flow model to the next higher level of complexity in the planning system, he was asked to make a decision on that issue as part of the data entry process and he responded appropriately. When the correct assumptions were put into the model, the division showed a much higher rate of return even though he had previously corrected for underestimating total working capital requirements.

The president said he felt that the time he spent in the process of division planning using the computer based decision support system was much more effective than similar investment planning experiences in the past using more conventional methods. These remarks were made even though the computer time sharing system that he was using had crashed four times during his computer-modeling and problem exploration periods, causing him to lose

painstakingly entered model data and parameters. These computer crashes irritated him greatly. He also complained about the slow, noisy communications terminal and about the fact that too many words were printed by the planning model during the conversational data entry process. Although the user guide for PROJECTOR is some ninety pages long, he felt that he could master most of the important system activities (he did not use the merger/acquisition model) without the manual after a few short terminal sessions. This was easy since the model was almost entirely English-language oriented and the system is completely self-documenting at the terminal. In case the model user doesn't understand what his options are in a particular PROJECTOR sub-model, he can type HELP for instructions that are related only to that sub-model.

Of profound importance to him were the capabilities of very rapidly performing sensitivity analysis, data manipulation, and profitability calculations as well as producing offline hardcopy reports on a project summary and period by period analysis scheme. He claimed that his time-effectiveness was improved over his original planning methods by a factor of at least twenty considering the total planning process and that sensitivity analysis could be performed in less than one per cent of the time required by his prior method of analysis (these are paraphrases of the president's actual words). He often kept an electronic calculator near the computer terminal so that he could do quick arithmetic calculations as he processed the problem or changed model input assumptions. Some computer model building and planning systems provide this capability on-line.* Another of his complaints about the system was that he could not add certain levels of complexity to the problem that were not allowed under the current version of the PROJECTOR model. These demands for added model flexibility

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*Such a capability is being implemented in the next version of PROJECTOR.

would have probably increased had the president not been so limited in time. As a final comment, he asserted that he would never under any circumstances have made such a thorough and confidence inspiring analysis of the various ramifications of his new division proposal had he not had the computational support, flexibility, and ease of operation of the interactive planning model.

INTERPRETATION OF RESULTS

In the case study just presented we see a fruitful application of a computer based planning support system to a managerial problem. The manager involved found the system useful in analyzing and coming to an understanding of his problems. We also found it a useful experience because of the feedback he was able to give us, in our role as systems designers and implementers, about how we might modify the system to make it even more effective.

In this particular situation this interaction between the manager and the system was the result of a fortuitous chance. The manager decided that a consultant might be useful, called him in, and the consultant happened to have a tool which fit comfortably with the manager's "style" of problem solving. This naturally leads us to the question of whether this match between the manager and the system could have been forseen, or whether the systems designers and implementers must always, in the final analysis rely on such chances.

Earlier in this paper we alluded to the issues related to human information processing, cognitive behavior, and affective or motivational characteristics, particularly as they relate to man-machine decision support or problem solving systems. We believe that the lack of any substantive attention paid to such issues in the past may help to explain, in part, the paucity of reports describing the success of interactive computer systems in cases where formal models are implemented on computers in support of high-level problem solving and decision making activities. By high-level we mean that the activities involved are important to the organizations in which they occur and the solution procedures are nontrivial. Such problems include corporate long range and strategic planning, public policy analysis, education, medical diagnosis, and of

course other classes of problems where no automatic decision making algorithms are available or appropriate to the solution. By their very nature, decision making and problem solving are essentially human activities.

We suggest that rather profound human and organizational implications are present when novel instrumentalities are brought to bear on organizational problems that are critical to the organizations in which they exist and where there is strong tradition in using other decision strategies for operating on these problems. Furthermore, we suggest that it is inappropriate to attempt to come to an understanding of man-machine decision systems without taking a hard look at the human side of the process in problem solving and decision making.

Several important technical and organizational factors come to bear on the success of a decision support system implementation. If these could be more easily identified and interpreted in a specific organizational setting, the information systems scientist or consultant might have a greater chance of success in implementing novel mechanisms for decision making and problem solving. A number of tests and measures have been developed for trying to achieve a better understanding of many human factor issues in implementation. These tests attempt to determine the relevance of such variables as cognitive style, learning style, attitudes and motivation as factors in implementing change processes in people and in organizations.

We believe it is time for researchers to begin serious investigation into human factor issues in the success or failure of interactive management decision support systems. Such research is already underway in studies of management acceptance of management science recommendations.

Previous research in cognitive psychology and management science implementation problems indicates that the nature of the researcher-manager interface may be related to measurable cognitive factors [10].

This naturally suggests that if, in the early stages of a system's use, we have a choice about what part of the user community is the most appropriate target for a system like PROJECTOR, such measures may prove fruitful. In the more common situation, where we do not have such a choice of who will be in the user community, we suggest that such tests may be useful in deciding on the approach to be taken to the prospective user. Particular aspects of the implementation affected by such information might include:

1) How to present the system to the user
2) How to train the user to use the system
3) What sub-models of the system to make the user aware of (initially)
4) In a system with a hierarchical language, which portions of the language to give him.

CONCLUSION

The investigation reported in this paper is of course but one experiment. Obviously, care must be taken in drawing general conclusions from the results. However, we feel that the study does tend to support some of the comments made early in the paper.

Much of the actual work here centered around the implementation of the PROJECTOR on-line planning system. This planning model was effectively used by a corporate president in planning certain aspects of a new product introduction and the associated creation and analysis of a new corporate division. As a direct result of the president's confidence in the model, he changed a critical marketing strategy and completely rewrote certain major aspects of the preliminary division plan.

The results of using the model were sometimes quite surprising to the president. He claimed that using the model had a significant educational impact on him forcing him to consider issues that he would not have thought of otherwise. In early versions of the model he discovered the extreme sensitivity of profitability to minor variations in inventory build up, and he therefore concluded that more initial capital would be needed and that he had greatly underestimated total project working capital requirements.

Although the president could not completely understand or predict all of the complex dynamic interactions caused by important structural data or parameter changes in the model, he proved to be effective at defining appropriate levels of aggregation, variable identification, and model parameterization. He was also able to make satisfactory estimates of pairwise relationships between variables, i.e., how would working capital requirements change with rapidly increasing sales if all other variables were held constant.

In retrospect, the important issues that came to the surface during the process of decision support system implementation in this specific case included:

The initial model implementation was critically dependent on the close support of the president's analysis activities by the consultant. However, after the initial phase was well under control, the president was able to do the majority of analysis with little more than the aid of the planning system user guide and an occasional phone call to the consultant to resolve minor confusions about using the system.

The president's personal problem solving style appeared to be a key issue in the decision as to what type of model was to be implemented. Although a stochastic simulation model was a reasonable candidate for treating certain aspects of the problem, the president felt less comfortable with it (and with its possible costs), than he did with making point estimates of model parameters and data, and then doing a sensitivity analysis on these.

It was absolutely imperative that the model user clearly understood the model he was using since no automatic decision making or optimization algorithm was available and since the planning process involved was extremely important to the organization. It turned out that starting with a very simple model of the problem and then progressively working toward more complex analytical descriptions in an evolutionary fashion was a critical component of the eventual success of the system implementation and the divisional planning process [as in Gorry (3)].

The importance of the learning process experienced by high level managers using sophisticated interactive models should not be underestimated when considering the overall impact of implementing decision support system technology. As the decision maker in this study became comfortable in using the interactive planning model and began to learn more about the divisional planning problem itself, he began to make more and more sophisticated demands on the system. These demands included much greater degrees of complexity in the structure and analysis of his analytical model than he originally had thought would be useful.

This situation leads us to believe that consultants, staff members, or teams who are responsible for design and implementation of high level computer based decision support systems should report directly to the decision maker(s) who will actually be final users of the system rather than to the head of the data processing department. This study indicated that one decision maker was able to effectively analyze a complex strategic planning problem using a sophisticated interactive MDS which he had no prior experience with, by virtue of close initial support from a systems consultant.

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```
EXECUTION BEGINS...

 PROJECTOR - AN ONLINE PLANNING SYSTEM FOR ENTERPRISE, ACQUISITION
             AND PROJECT ANALYSIS

 ENTER COMMAND LEVEL OPTION:
>FORECAST MOD

 FORECAST COMMAND OPTION:
>REGRESSION   COMMENT -- NUMBER OF USERS OF TARGET PRODUCT IN U. S.

 REGRESSION DATA ENTRY INSTRUCTIONS? (YES NO)
>YES

 ENTER INPUT DATA IN X,Y PAIRS.
 X IS THE INDEPENDENT VARIABLE.
 Y IS THE DEPENDENT VARIABLE.

 THE REGRESSION EQUATION IS:     Y = A + B * X

 SIGNAL END OF DATA ENTRY BY TYPING AN EMPTY-LINE
 CARRIAGE RETURN. TYPE ONLY ONE X,Y DATA PAIR PER LINE
 AS THE COMPUTER REQUESTS THE DATA. SEPARATE X,Y DATA
 POINTS WITH COMMAS.

 DATA X,Y:
>1960,33

 DATA X,Y:
>1965,45

 DATA X,Y:
>1968,64

 DATA X,Y:
>1969N75

 PLEASE RE-ENTER THE LAST PAIR OF DATA POINTS.

 DATA X,Y:
>1969,75

 DATA X,Y:
>1970,78

 DATA X,Y:
>1971,80

 DATA X,Y:


 END OF DATA ENTRY? (YES NO)
>YES
```

FIGURE 1

Regression Analysis with the PROJECTOR
Forecast Model
(User input is underlined)

```
REGRESSION CALCULATIONS BEGIN.

REGRESSION RESULTS

COEFFICIENTS    A =    -12276.867187    B =          6.272656

REGRESSION EQUATION:  Y  =     -12276.8672  +  (          6.2727 )  *  X

COEFFICIENT OF DETERMINATION (R-SQUARED) =  0.7894

STANDARD ERROR OF REGRESSION =          8.901609

FORECAST COMMAND OPTION:
FORECAST REGRESSION    COMMENT -- 5 YEAR FORECAST OF TOTAL USER POPLN IN U.S.

KEEP CURRENT REGRESSION INPUT DATA? (YES/NO)
YES

USE CURRENT REGRESSION COEFFICIENTS? (YES/NO)
YES

HOW MANY TRIAL VALUES DO YOU WISH TO SIMULATE?
5

DATA X:
1972,1973,1974,1975,1976

END OF DATA ENTRY? (YES NO)
YES

REGRESSION MODEL CALCULATIONS BEGIN


TABLE OF REGRESSION MODEL SIMULATION RESULTS

X - ACTUAL VALUES OF X ENTERED AS INPUT DATA
    OR MODEL SIMULATION TRIAL VALUES
Y - ACTUAL VALUES OF Y ENTERED AS INPUT DATA
YEST - ESTIMATED VALUES OF Y FROM THE REGRESSION MODEL
```

X	Y	YEST
1960.000000	33.000000	17.542969
1965.000000	45.000000	48.906250
1968.000000	64.000000	67.722656
1969.000000	75.000000	73.996094
1970.000000	78.000000	80.269531
1971.000000	80.000000	86.539063
1972.000000	0.0	92.812500
1973.000000	0.0	99.085938
1974.000000	0.0	105.359375
1975.000000	0.0	111.632812
1976.000000	0.0	117.902344

FIGURE 1 (Cont'd)

Regression Analysis with the PROJECTOR
Forecast Model

FORECAST COMMAND OPTION:
PLOT REGRESSION   COMMENT -- TOTAL TARGET PRODUCT SALES IN U. S.

PLOT OF REGRESSION RESULTS

A - ACTUAL INPUT DATA
B - ESTIMATE FROM REGRESSION EQUATION

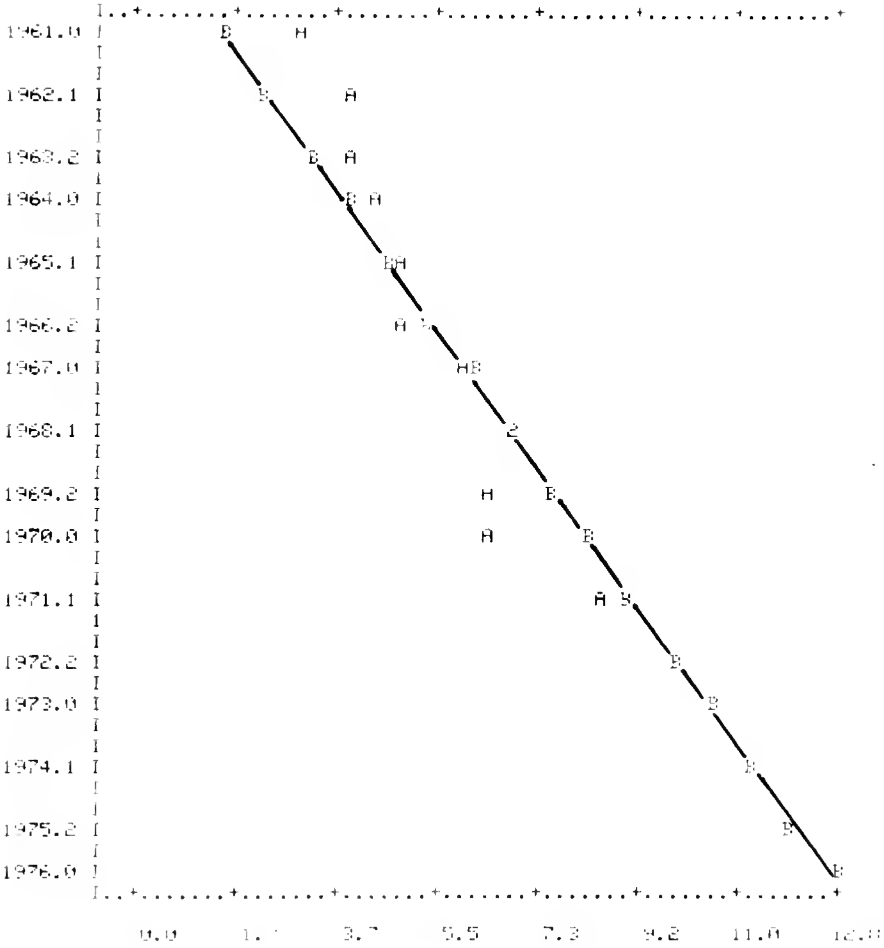

FIGURE 2

Graphical Output of Regression
Model Results Versus Actual Data

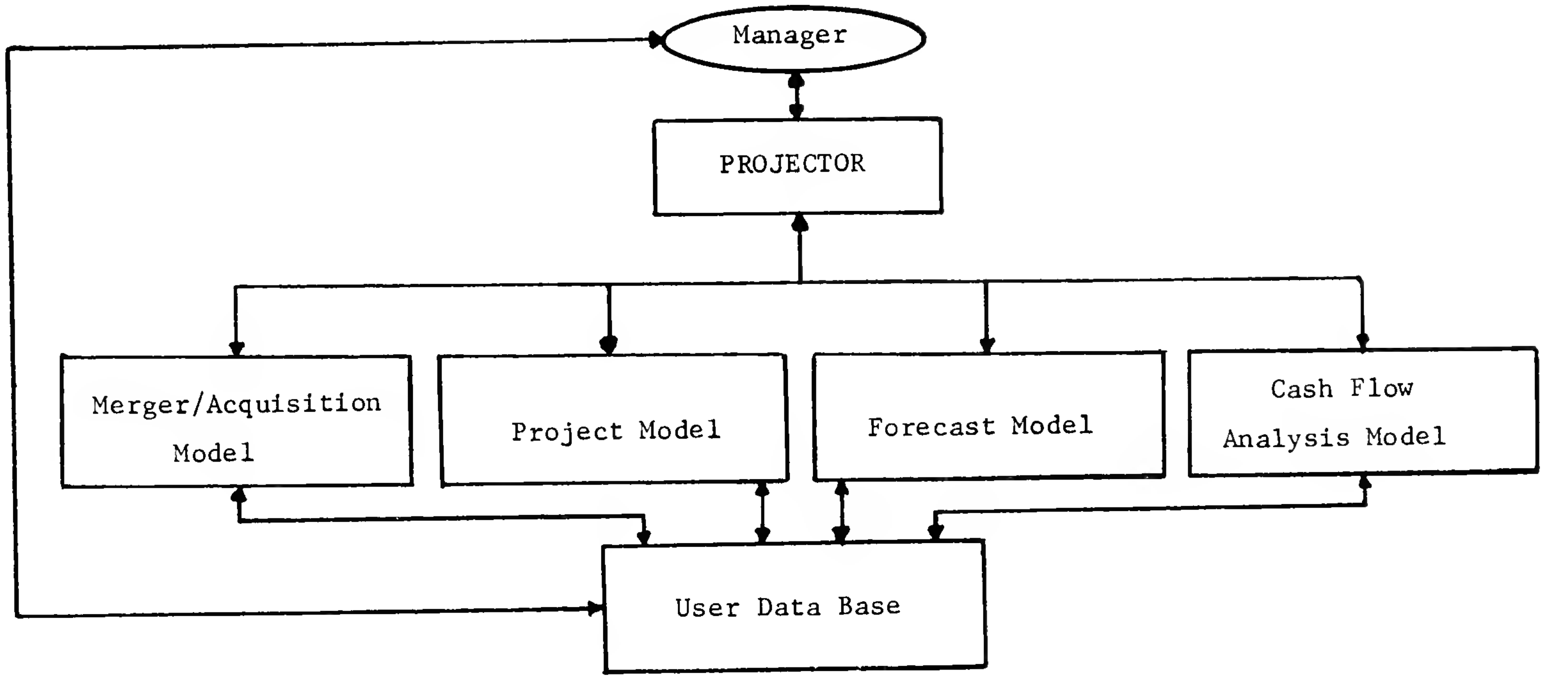

FIGURE 3 PROJECTOR System Information and Control Flow

```
PROJECT MODEL COMMAND OPTION:
>IRR

INTERNAL RATE OF RETURN        1[illegible] PER CENT

PROJECT MODEL COMMAND OPTION:
NET PRESENT VALUE

ENTER THE APPROPRIATE MARGINAL RATE OF RETURN(%):
>15

NET PRESENT VALUE OF CASH FLOWS          4.

PROJECT MODEL COMMAND OPTION:
>NET PRESENT VALUE

ENTER THE APPROPRIATE MARGINAL RATE OF RETURN(%):
>8

NET PRESENT VALUE OF CASH FLOWS        185.

PROJECT MODEL COMMAND OPTION:
>SENSITIVITY

SENSITIVITY ANALYSIS COMMAND OPTION:
>PER CENT CHG.

DO YOU NEED INSTRUCTIONS FOR THE DATA ALTERATION PROCEDURE? (YES/NO)
>NO

DATA ENTRY TO BE CHANGED:
>SALES

ENTER PERCENT CHANGE WITH A PLUS(+) OR MINUS(-) SIGN:
>+25

DO YOU WISH TO CHANGE ANY CURRENT DATA ENTRIES? (YES/NO)
>NO

SENSITIVITY ANALYSIS COMMAND OPTION:
>PROJECT MOD

PROJECT MODEL COMMAND OPTION:
>IRR

INTERNAL RATE OF RETURN        27.67 PER CENT

PROJECT MODEL COMMAND OPTION:
>NET PRESENT VALUE

ENTER THE APPROPRIATE MARGINAL RATE OF RETURN(%):
>15

NET PRESENT VALUE OF CASH FLOWS        205.

PROJECT MODEL COMMAND OPTION:
>NET PRESENT VALUE

ENTER THE APPROPRIATE MARGINAL RATE OF RETURN(%):
>8

NET PRESENT VALUE OF CASH FLOWS        421.
```

FIGURE 4

Discounted Cash Flow Investment Analysis
Commands and Sensitivity Analysis in the
PROJECTOR Project Model

```
FORECAST COMMAND OPTION:
EXPONENTIAL SMOOTHING [illegible] TARGET [illegible]

EXPONENTIAL SMOOTHING DATA ENTRY INSTRUCTIONS? (YES/NO)
YES

ENTER INPUT DATA POINTS SEPARATED BY COMMAS.
SIGNAL END OF DATA ENTRY BY TYPING AN EMPTY-LINE
CARRIAGE RETURN.

THE EXPONENTIAL SMOOTHING EQUATION IS

X(T+1) = ALPHA * X(T) + (1.0 - ALPHA) * XHAT(T)

WHERE ALPHA IS THE SMOOTHING CONSTANT, X(T) IS THE PREVIOUS
VALUE OF X, AND XHAT(T) IS THE PREVIOUS ESTIMATE OF X.

ENTER EXPONENTIAL SMOOTHING CONSTANT:
.5

DATA:
3,4,4,4.5,5,5,6,7,6.5,6.5,8.6
END OF DATA ENTRY? (YES/NO)
YES

EXPONENTIAL SMOOTHING CALCULATIONS BEGIN

PRINT EACH CALCULATION ITERATION RESULT, INCLUDING
ERROR TERMS? (YES/NO)
NO


EXPONENTIAL SMOOTHING RESULTS

NEW ESTIMATE OF DATA (HAT( 12) =          7.511913
SUM OF THE ERROR SQUARED TERMS =         11.696734


TRY AGAIN WITH NEW EXPONENTIAL SMOOTHING CONSTANT? (YES/NO)
NO

FORECAST COMMAND OPTION:
OPTIMAL ALPHA

OPTIMAL ALPHA     0.989999056

EXPONENTIAL SMOOTHING CALCULATIONS BEGIN

PRINT EACH CALCULATION ITERATION RESULT, INCLUDING
ERROR TERMS? (YES/NO)
YES
```

NO.	XHAT(T)	X(T)	ERROR	ERROR SQ
1	3.000000	3.000000	0.0	0.0
2	2.999999	4.000000	-1.000001	1.000002
3	3.989999	4.000000	-0.010001	0.000100
4	3.999900	4.500000	-0.500100	0.250100
5	4.494997	5.000000	-0.505003	0.255028
6	4.994948	5.000000	-0.005052	0.000026
7	4.999949	6.000000	-1.000051	1.000103
8	5.989998	7.000000	-1.010002	1.020103
9	6.989898	6.500000	0.489898	0.240000
10	6.504899	6.500000	0.004899	0.000024
11	6.500049	8.599999	-2.099951	4.409793
12	8.578997	0.0	0.0	0.0

```
EXPONENTIAL SMOOTHING RESULTS

NEW ESTIMATE OF DATA (HAT( 12) =         8.578997
SUM OF THE ERROR SQUARED TERMS =         8.175277


TRY AGAIN WITH NEW EXPONENTIAL SMOOTHING CONSTANT? (YES/NO)
NO
```

FIGURE 5

Exponential Smoothing with Calculation of Optimal Smoothing Coefficient in the PROJECTOR Forecast Model

FORECAST COMMAND OPTION:
PLOT EXPONENTIAL SMO COMMENT - TOTAL TARGET PRODUCT SALES IN U. S.

PLOT OF EXPONENTIAL SMOOTHING RESULTS

A - ACTUAL INPUT DATA
B - ESTIMATE FROM EXPONENTIAL SMOOTHING EQUATION

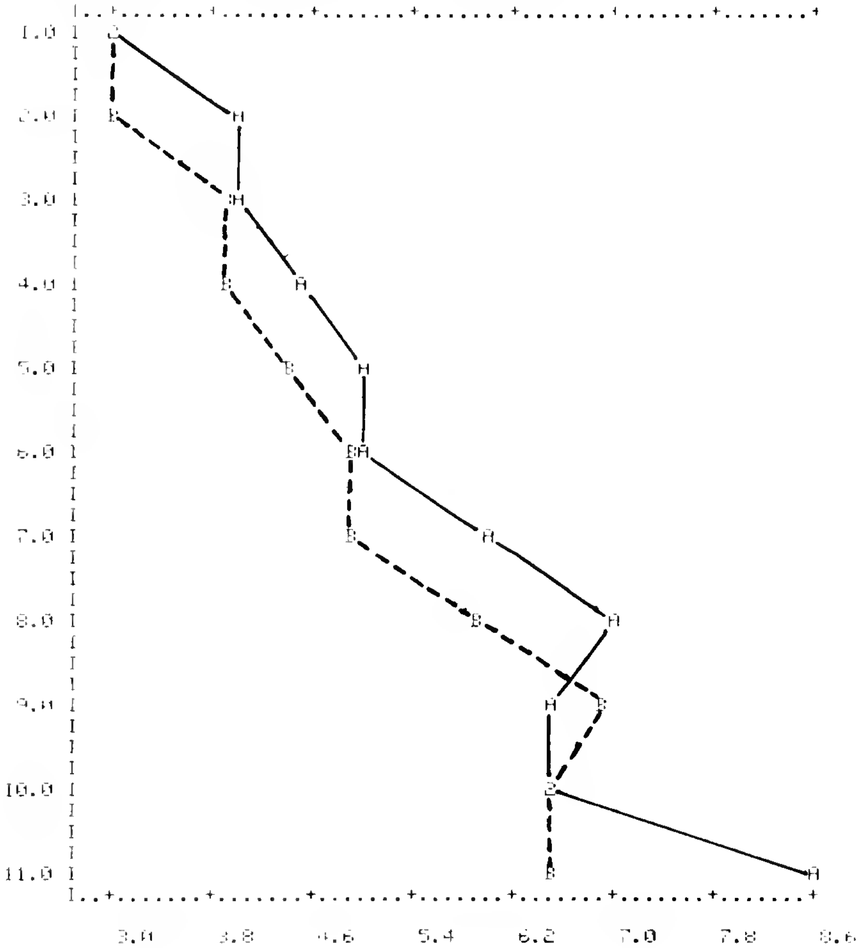

FIGURE 6

Graphical Output of Exponential Smoothing Model Results Versus Actual Data

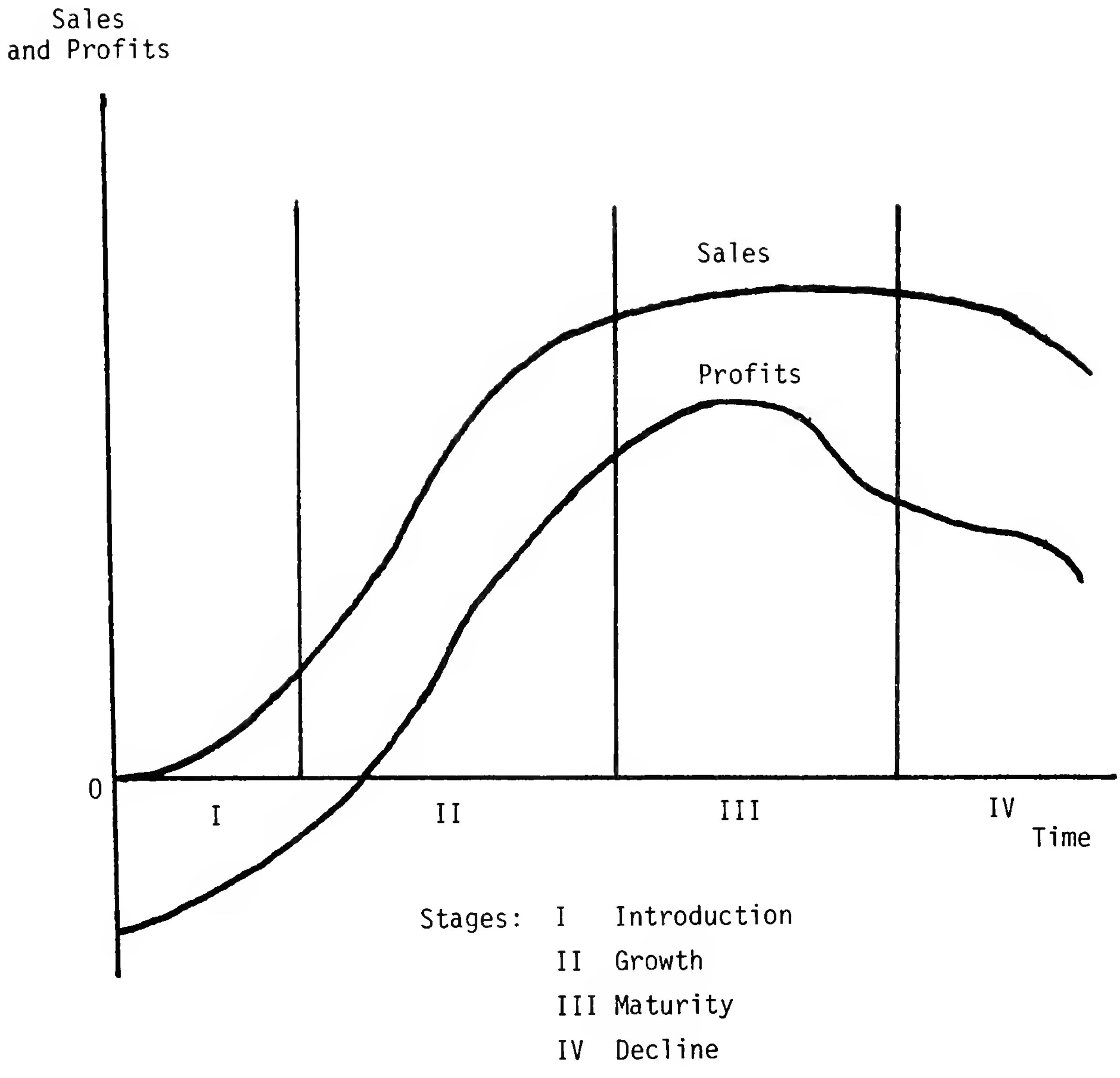

FIGURE 7

Product Life Cycle and
Corresponding Profit Life Cycle

Table 1. <u>Merger/Acquisition Optimization Model</u>

- -- Goal Programming Package Determinator
  - Capital Structure Specifications
  - Goal Programming Sensitivity Analysis
  - Multiple Objectives
  - Opportunity Costs
  - Penalty/Reward Functions
  - Target/Goal Variables
    - Cash Outlay
    - Earnings Per Share Dilution
    - Percentage Ownership
    - Post-Merger Debt/Equity Ratio
    - Security Package Specifications
      - Bonds
      - Common Stock
      - Convertible Preferred Stock
    - Working Capital Requirements
- -- Post-Acquisition Forecasted Results
- -- Pre-Acquisition Trend Analysis
- -- Ratio Analysis
- -- User Directed Sensitivity Analysis

Table 2. Project Model

-- Additional Recovery Values

-- Costs Tied To Revenue Flows

-- Depreciation

-- Discounted Cash Flow Investment Analysis

- Annual Present Values
- Benefit/Cost Ratio
- Cumulative Present Values
- Internal Rate Of Return
- Net Present Value
- Payback Period

-- Graphics On All Periodic Data

-- Investment Tax Credit

-- Marginal Rates Of Return

-- Ratio Analysis

- Activity Ratios
- Liquidity Ratios
- Profitability Ratios

-- Recovery Of Fixed Investment

-- Recovery Of Working Capital

-- Reports

- Period By Period And Total Project Discounted Cash Flow Investment Analysis
- Period By Period Working Capital Investment Analysis
- Period By Period Disaggregated Investment Profile
- Project Model Input Parameters
- Income Statements And Balance Sheets

-- Risk

-- Sensitivity Analysis On All Project Input Data And Parameters

-- Tax Credit/Tax Carry Forward Optimal Allocation

-- Tax Loss Carry Forward

-- Working Capital Factors

  - Accounts Payable
  - Accounts Receivable
  - Cash
  - Inventory
  - User Supplied Procedures

Table 3. <u>Forecast Model</u>

- -- Exponential Smoothing
  - - Double Exponential Smoothing
  - - Second Order Exponential Smoothing
  - - Simple Exponential Smoothing
  - - Triple Exponential Smoothing
- -- Graphics
  - - Exponential Smoothing Results Vs. Actual Data
  - - Regression Model Results Vs. Actual Data
- -- Multivariate Regression Models
- -- Optimal Exponential Smoothing Constant
- -- Optimal Exponential Smoothing Method
- -- Statistical Analysis Of Data And Model Results
- -- Univariate Regression Models

Table 4. Cash Flow Model

-- Annual Present Value Of Cash Flows

-- Average Project Results

-- Benefit/Cost Ratio

-- Cumulative Present Value Of Cash Flows

-- Graphics

  - Annual Present Values

  - Cash Flow

  - Cumulative Present Value

-- Net Present Value

-- Payback Period

-- Report Discounted Cash Flow Investment Analysis On A Period By Period And Project Summary Basis

-- Total Project Benefit

no. 675-73 CANCELLED